(12) UK Patent Application (19) GB (11) 2 092 099 A

(21) Application No **8136653**
(22) Date of filing **4 Dec 1981**
(30) Priority data
(31) **8025951**
(32) **5 Dec 1980**
(33) **France (FR)**
(43) Application published **11 Aug 1982**
(51) **INT CL³ B66C 23/94**
(52) Domestic classification **B8H** 202 203 210 213 553 BA
(56) Documents cited
GB 1564048
GB 1456174
GB 1432574
GB 1218798
(58) Field of search **B8H**
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(54) A hoisting apparatus for use in a confined space and including a cantilevered telescopic boom

(57) Hoisting apparatus, more particularly for use in a nuclear power plant to avoid moving suspended loads through the space above the reactor tank (2), comprises, mounted on a stationary structure (5) of said plant, a crane (7) having a telescopic boom (8) and three security systems, respectively an orientation security system (SSO) for forbidding a determined angular range θ in angular lateral displacement when the boom reach is greater than P_m, a boom raising security system (LRF) limiting the raised position of the boom to a predetermined level, and a load state control (CEC) for insuring a permanent control with automatic cut-off for the boom in dependence of its extension length and of the lifted loads. Said security systems may be selectively inhibited. All the manoeuvring and indicating means are grouped on a transportable remote control operator console.

Fig: 1

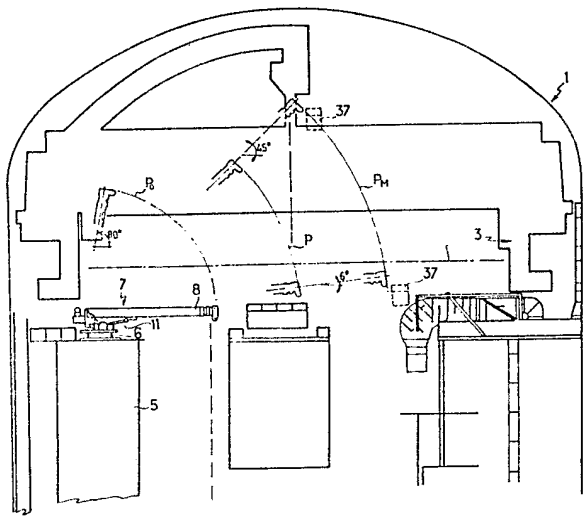

Fig: 2

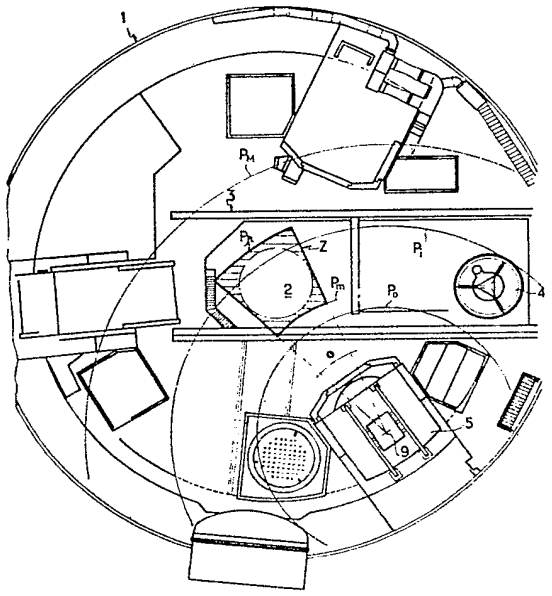

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Fig: 1

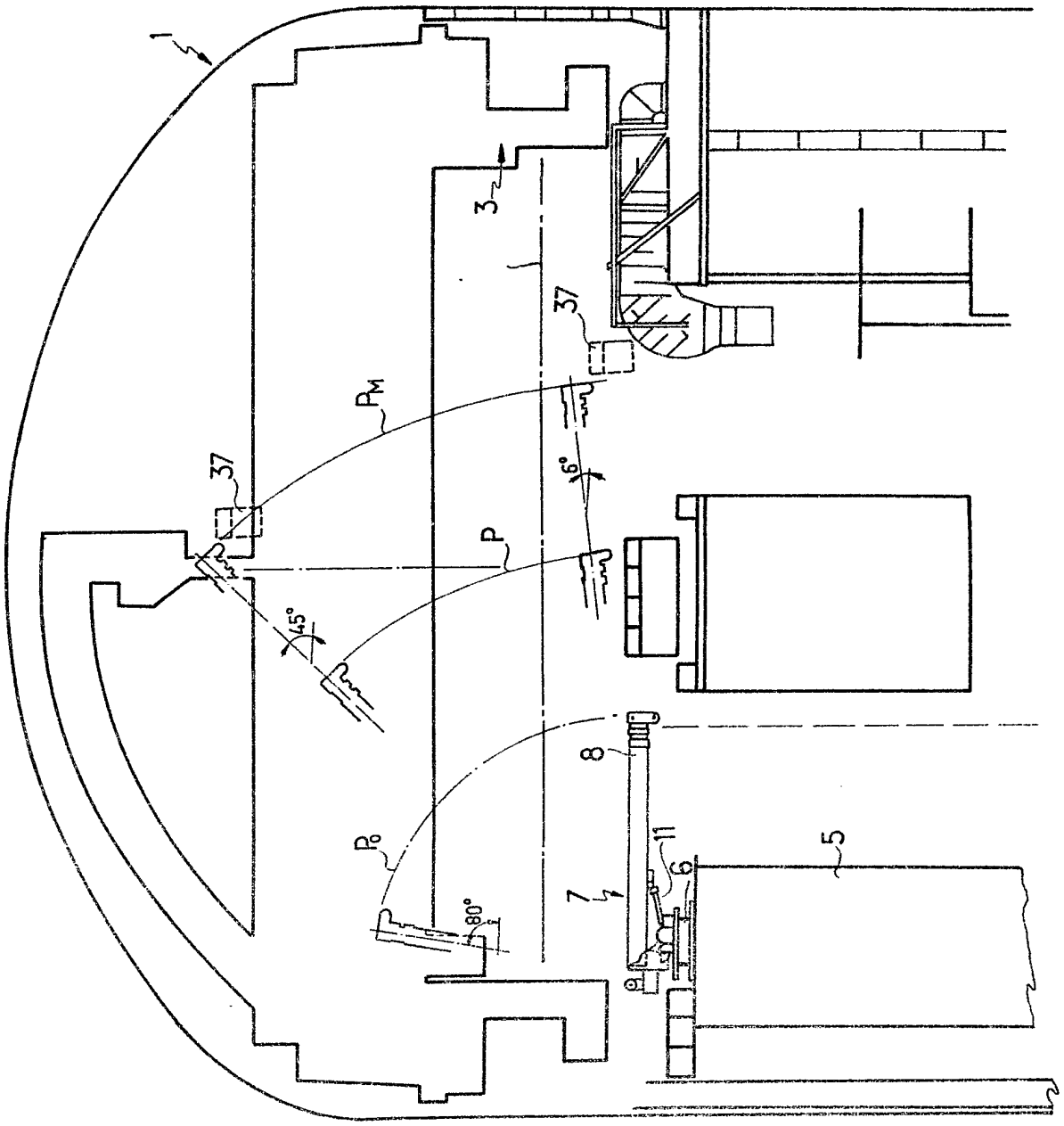
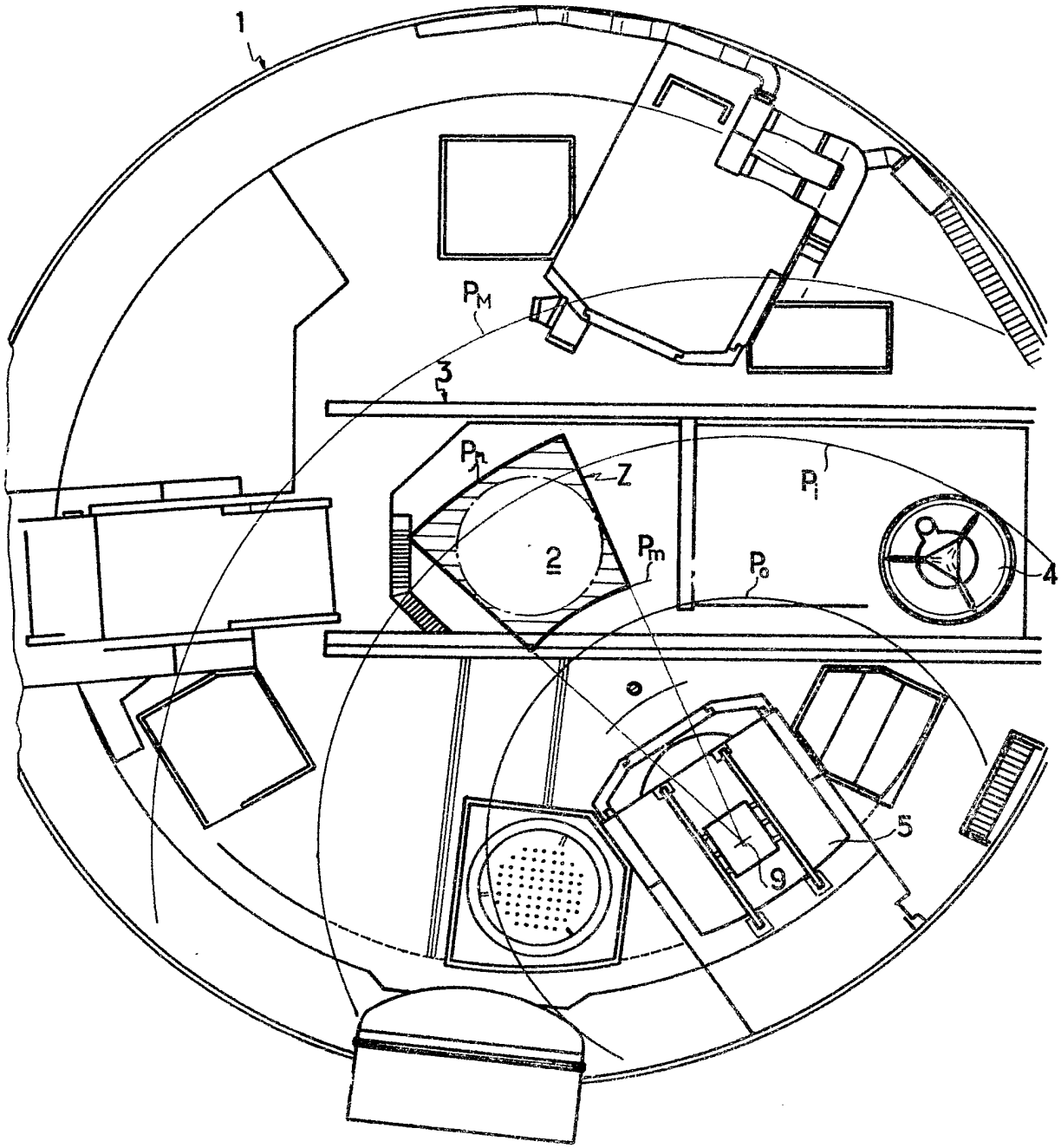


Fig: 2



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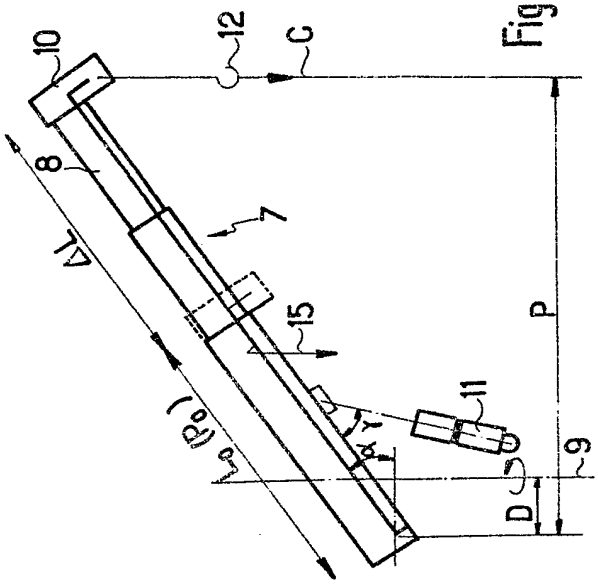
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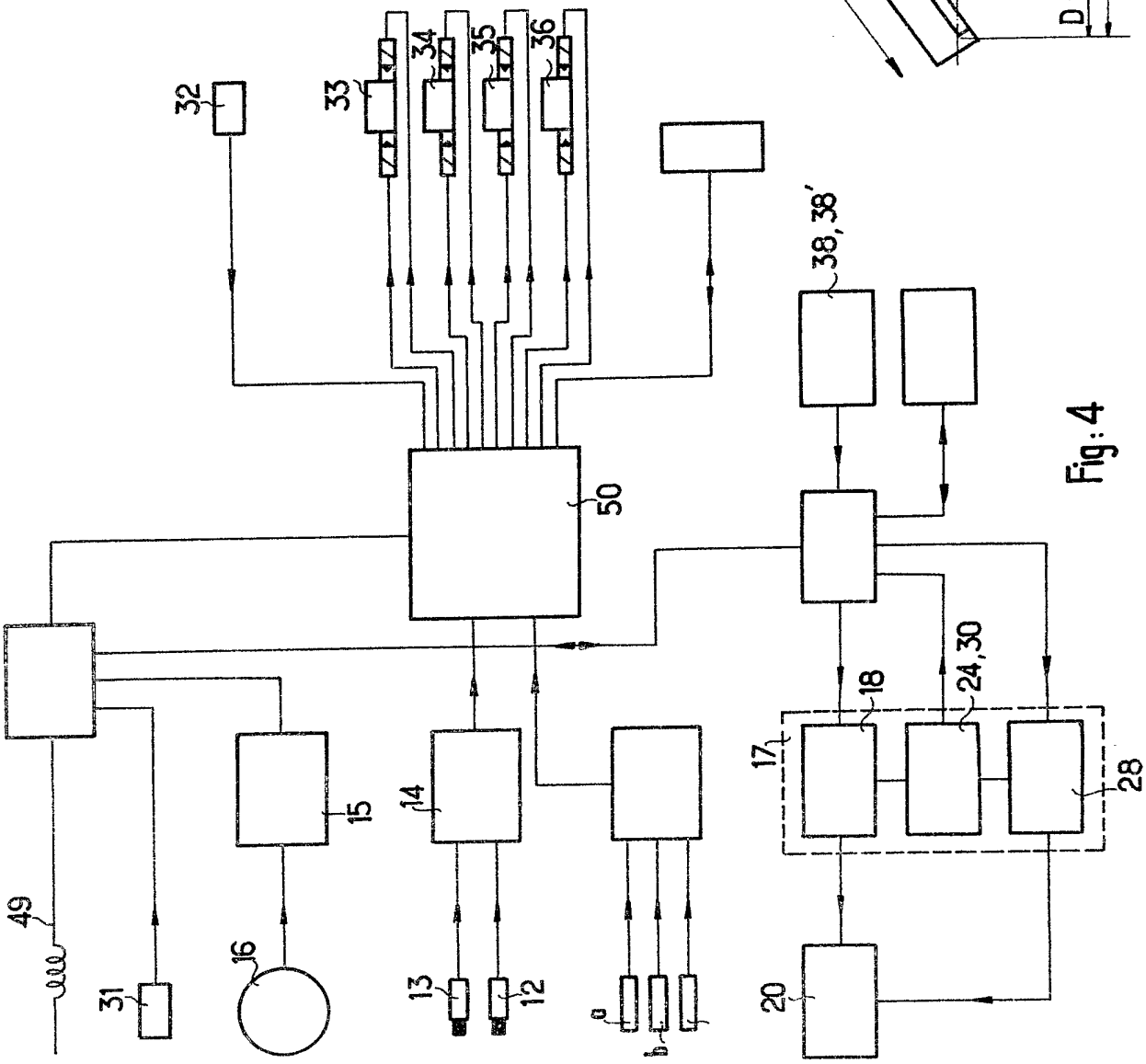
Fig: 4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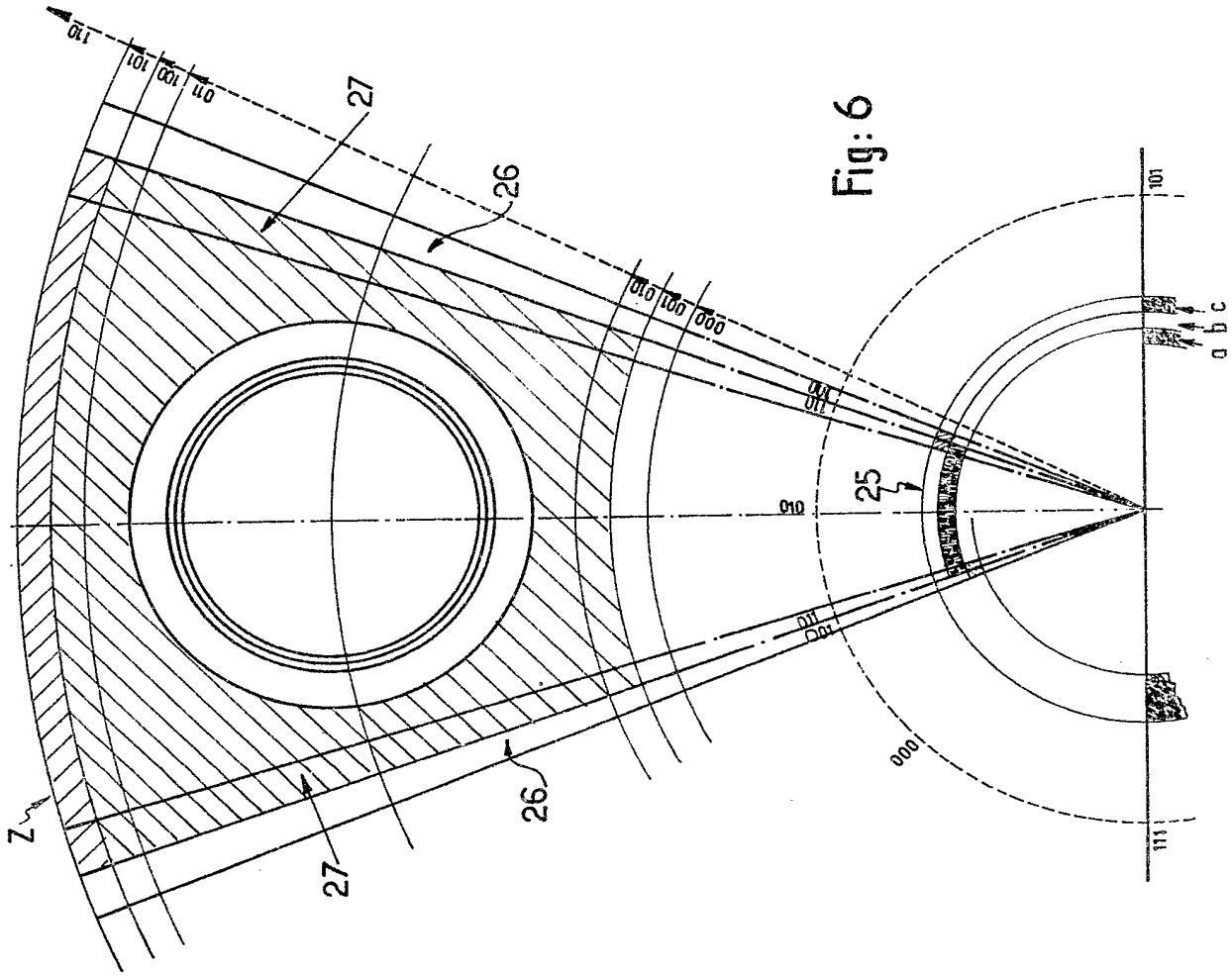
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Fig: 6

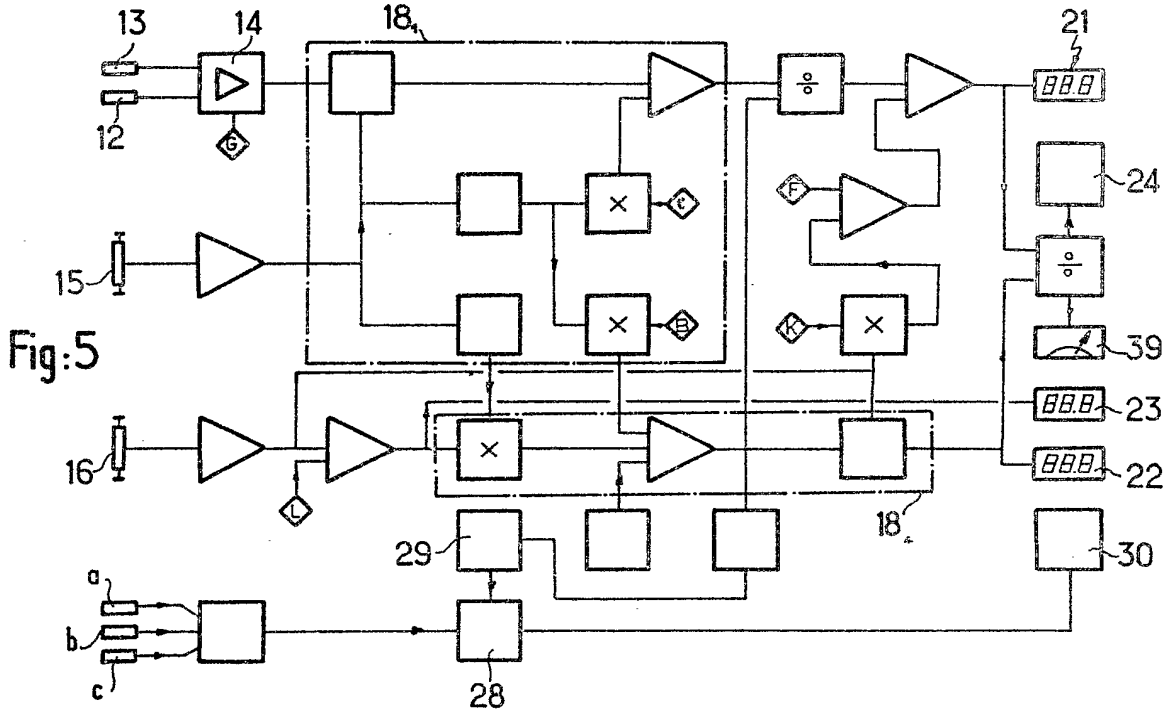
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Fig: 5

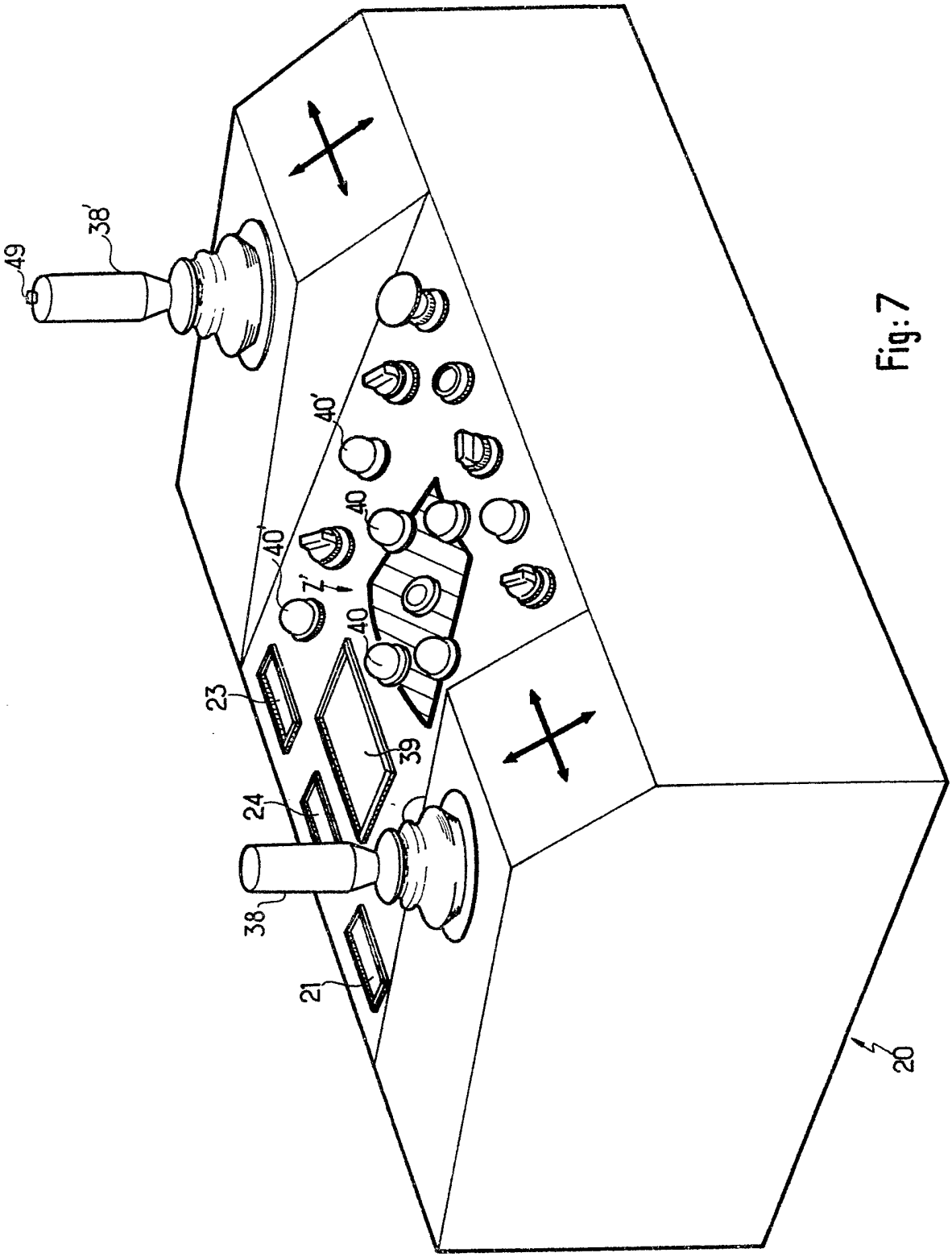

Fig:7

SPECIFICATION

Hoisting apparatus for use in a confined space and including a cantilever telescopic boom

This invention relates to a crane type hoisting apparatus having a cantilevered boom, and more particularly a telescopic boom, for use in confined spaces.

Utilization of a hoisting apparatus of the crane type in a confined space presents problems, more particularly as concerns limitations upon the angular and extension displacement ability of the crane boom owing to the presence of stationary structures or assemblies, of the boom itself or on other equipment installed in the space. In a number of particular cases, more particularly in nuclear power plants, some sensitive zones must not be over flown by suspended loads, as is the case, in a reactor building, for the space above the reactor tank. Premises having confined spaces wherein loads have to be handled or displaced, generally comprise a built-in travelling crane or bridge displaceable along runways adjacent the ceiling and designed with respect to the main loads to be handled within the premises. This is the case with the reactor building of a nuclear power plant, which comprises a heavy travelling bridge serving for the initial installation of the plant, and more particularly for placing and mounting the reactor tank. Such a travelling bridge crane, as above mentioned, is heavily dimensioned and is accordingly awkward to utilize; moreover it has very slow displacement rates and in consequence a heavy power consumption. Now, whatever premises are considered, there is a permanent need for the handling and hoisting of small or medium loads in a confined space, more particularly for installing or withdrawing auxiliary items of equipment.

The invention intends to provide a hoisting apparatus adapted for use in a confined space and having a certain number of automatic securities for ensuring optimum and reliable utilization while taking into account the above mentioned imposed limitations of angular or reach displacements.

The invention also intends to provide an auxiliary hoisting apparatus for use in nuclear power plants, which exhibits an improved safety in conformation with nuclear standards and includes automatic means for detecting and controlling manoeuvres of the crane boom and of the hoisted loads so as more particularly to prevent any undesired flight of suspended loads over the zone above the reactor tank and thereby to eliminate the risks of damaging the installations inside the reactor building, more particularly the pre-existing travelling bridge, and the hoisting apparatus itself.

With these and other intentions, according to the invention a crane type hoisting apparatus comprises a cantilever boom crane means mounted on a stationary support inside the confined space and includes, coupled to the boom actuating means, a first automatic detecting and controlling means for prohibiting the crane boom from describing in a lateral displacement at least a determined angular range.

According to another feature of the invention, the hoisting apparatus comprises crane means having a telescopic boom and includes a safety automatic means for detecting the load suspended from the crane and for controlling operation of the crane booms in dependence upon the detected load value and of configuration conditions of the boom.

According to another feature of the invention, there are associated with these different automatic detecting and controlling means displaying and warning devices grouped on a separate transportable console which includes manoeuvring input means for manoeuvring the hoisting apparatus.

Other features and advantages of the present invention should be evident from the following description, by way of example, of a preferred embodiment which is illustrated in the accompanying drawings, wherein:

Figures 1 and 2 schematically illustrate in vertical cross section and in plan, respectively, the general location of an auxiliary hoisting apparatus according to the invention in a nuclear reactor building;

Figure 3 is a schematic view illustrating the physical parameters of the hoisting apparatus which are taken into account by the safety detecting and controlling means of the hoisting apparatus;

Figure 4 is a block diagram which schematically illustrates the detecting and controlling means;

Figure 5 is a block diagram which further illustrates the displaying or warning means associated with the detecting and controlling means;

Figure 6 schematically illustrates the geometrical lay-out of the crane boom orientating securities; and

Figure 7 is a perspective view of a centralized control and display console for controlling the hoisting apparatus.

There is schematically illustrated in Figures 1 and 2 a general location of an auxiliary hoisting apparatus according to the invention in a nuclear reactor building, of which the dome-forming concrete enclosure is schematically shown. Within this building is centrally arranged a reactor tank 2, which the loads suspended from the auxiliary hoisting apparatus must normally not fly over. In the upper portion of the building 1 is installed a conventional heavy travelling bridge 3 which extends horizontally up to above the reactor tank and which serves more particularly to lift and displace the apparatus for handling the tank cover 4. According to the invention, onto the upper surface of a stationary structural construction 5 inside the building, for instance the masonry frame of a steam generator, there is mounted, *via* a supporting revolving turret 6, a crane 7 having a telescopic boom 8. The crane boom has in its fully retracted condition a minimum reach L_0 so that the corresponding lateral angular displacement circle P_0 centered on the vertical rotational axis 9

of the crane remains on this side of the forbidden zone Z having an angular spread θ (as taken from axis 9), which has the form of a portion of an annulus circumscribing the horizontal periphery of the tank 2. In an intermediary extending configuration, the distal end of the boom 10 may normally travel along a circle P_i passing over the tank 2, while in the fully extended horizontal condition, the boom end may travel along a circle of maximum radius P_M so as to reach at will the major portion of the serviceable inner space in the reactor building. In addition to the forbidden zone Z, corresponding to the middle lateral angular displacement range of the boom and to the inner and outer limit reaches P_m and $P\mu$ respectively, an additional security limitation has to be imparted to the crane boom as concerns its vertical angular displacement so that the boom cannot exceed a maximum elevation in order to prevent the boom from interfering with the components of the travelling bridge 3 or dependencies from it.

According to the invention, the hoisting apparatus comprises three kinds of securities, e.g. an orientation or direction security system (SSO) adapted automatically to prevent the boom from entering the area of angular range θ when the boom reach is greater than P_m, a boom raising security system (LRF) adapted automatically to prevent, in normal operation conditions, the boom from extending above a horizontal plane λ, and a load state control system (CEC) adapted to prevent any possibility of manoeuvring the crane boom in the case of detected overloading conditions according to a programme established to determine the admissible loads to be lifted in dependence upon the different possible extensions or reaches of the telescopic boom by detecting the actual extension length L_i of the boom 8, the raising angle α of the boom, the angle γ between the boom and the boom raising cylinder 11, and also the actual value of the load suspended to the load lifting hook 12 of the crane. The hoisting apparatus comprises power and control means — known in the art — for controllably rotating the crane, for selectively raising the boom, extending or retracting the boom sections, and for lifting or lowering loads suspended from the hook.

As illustrated in Figures 4 and 5, the load state control system (CEC) comprises two pressure transducers of the 0—600 bars class, typically of strain gauge type, mounted on the boom raising or lifting cylinder 11, e.g. a transducer 12 and a transducer 13 disposed in the large and small chambers of the cylinder, respectively. The outputs of the pressure transducers are connected to an amplifying unit 14 which furnishes an output signal proportional to the differential pressure between the cylinder chambers, as detected by the transducers. The control system further comprises a detector 15 for continuously detecting the raising angle α of the boom, which includes advantageously a gravimetric pendulum associated with a sliding contact potentiometer which furnishes an electrical output signal of a magnitude proportional to the vertical angle a of the boom, and a detector 16 for detecting the extension length of the boom, which comprises advantageously a winding wheel associated with a rotational potentiometer so as to furnish an electrical output signal proportional to the telescopic length L_i of the telescopic boom. A calculation unit 17 centralizes and processes the different output signals from the detectors and transducers to elaborate crane operation stopping order signals and actuate the respective warning and displaying devices on the operator control console 20. The reach of the telescopic boom and the weight of the load suspended from the hook 12 are computed in microprocessors 18_1 and 18_2 in dependence upon the measured parameters, as also of load profiles and of profiles of the angle γ between the boom lifting cylinder and the boom which are stored in registers in the calculation unit so as to elaborate warning signals which are displayed on the centralized operator control console 20: in the embodiment shown, at position 21 is displayed the measured load suspended to the hook, at position 22 the admissible lifting load (depending on the instantaneous configuration of the boom) and at position 23 the actual boom length, these indications being displayed (L.E.D.'s or liquid crystal display) in a digital form directly in tons and metres, respectively. The output warning signals resulting from the processing of the measured data are supplied to a warning and cutting-off unit 24 which is operated so as automatically to inhibit further manoeuvring of the boom upon the occurrence of the detected critical conditions while simultaneously warning the crane operator by means of pilot lights on the console and advantageously also by a buzzer (not shown). The boom length is advantageously measured and displayed with a precision of 0.1 m, the load being measured and displayed with a precision of 0.1 ton. A first indicating warning light (yellow light 40) is further advantageously provided on the console so as to indicate to the operator that the crane is being operated in conditions corresponding to a working rate at 90% of the critical conditions, a second warning light (red light 40') being actuated concomittently to the cut-off signal when a said critical condition is reached, this cut-off signal cutting off any lifting/lowering displacement of the load, and/or extension/retraction and raising/lowering displacement of the boom. The actual working rate, as measured and computed, may be advantageously continuously displayed by an indicating device 39 on the operator console.

In some conditions, more particularly for performing overloading tests, the load state control system can be de-activated by means of a consigned key on the console, whereby all the indications furnished by the control system are retained, but only the cut-off output signal is inhibited. There will be further advantageously provided an additional warning device indicating a failure of the main integers of the control system.

The orientation security system (SSO) is

provided for automatically preventing the end of the boom 10 from manoeuvring a suspended load above the forbidden zone Z. Since the crane 7 is stationarily supported and since load manoeuvres have to be permitted on the other opposite side of the forbidden zone, scanning of the forbidden zone by the boom body has to be kept possible. These functions are achieved by detecting the exact actual position of the boom end in a horizontal plane and by stopping movements of the boom which would tend to bring the boom end having a load suspended thereto above the forbidden zone Z having the horizontal angular range θ. On the other hand, the movements of the boom end which tend to displace the latter aside from the forbidden zone are allowed. The forbidden angular sector θ is inscribed by cam means 25 on the frame of the crane turret. The two limit reaches (P_m, $P\mu$) are registered within a logic unit of the orientation security system. In practice, a partitioning with additional border zones (Figure 6) on the periphery of the actual forbidden zone Z is required in order to permit selection of the possible or forbidden displacements of the boom and to actuate an approach warning device indicating that the boom approaches the forbidden zone. Detection of the additional border zones is achieved, as concerns the lateral angular orientation, by means of three proximity detectors *a*, *b* and *c* adapted for cooperation with cam sectors 25 so as to define coded zones, e.g. left and right approach zones 26 and 26′ for actuating a light and/or sound warning device without however cutting off at that stage lateral driving of the boom, and right and left orientation cutting-off zones 27 and 27′, for which lateral driving of the boom is automatically interrupted. A similar partitioning is achieved as concerns the variations of the reach of the telescopic boom by utilizing the reach signals indicative of the actual boom reach elaborated by the above mentioned load state control system. Signals from detectors *a*, *b*, *c* are transmitted to a logic processing unit 28 which is piloted by a priority encoder 29 in the calculation unit 17, so as to generate signals actuating the warning and orientation cutting-off device 30. The security control system further comprises upper and lower end of travel detectors 31 and 32, respectively, for detecting upper and lower limit positions of the lifting hook 12. Control and cutting-off of the manoeuvres of the crane is achieved by servo-valve means, e.g. a load lifting servo-valve 33, a boom orientation servo-valve 34, a boom tilting servo-valve 35 and a boom telescoping servo-valve 36, these servo-valves being all connected to a control box 50 which receives the output signals from the cutting-off actuator 24 and from the calculation unit 17.

Most of the usual manoeuvres of the crane will not be monitored by the orientation security system (SSO). On the other hand, in order to achieve handling of loads beyond the forbidden zone Z (as seen from the crane turret 6), the operator has to direct the boom to cause the boom end to pass round the forbidden zone, either visually or in following the approach indicating lights on the control console. As for the load state control system, inhibition of the orientation security system is possible by means of a convenient key inserted in the console; this inhibition will be indicated by an intermittent red light on the console (not shown).

In order to prevent the crane boom from colliding with the travelling bridge, the hoisting apparatus further comprises a boom raising security system (LRF). Accordingly, the maximum top limit, corresponding typically to a raising angle α of 6° of the boom, is controlled by an electrical end-of-travel or limit switch which directly cuts off the boom raising servo-valve 35 which controls the raising cylinder 11. This limit switch (not shown) is located on the side of the turret and acts directly onto the servo-valve 35 without its output stop signal passing *via* the control console in order to warrant operation reliability. This switch may be inhibited by means of a consigned key in order to permit utilization of the crane with a person-carrying gondola 37 mounted at the end of the boom, or with the boom fully raised, as illustrated in Figure 1, in order to reach, when required, the upper works of the building. There will also advantageously be provided a mechanical stop for limiting downward angular displacement of the boom not below a determined lower position, where the boom extends for instance at 4° with respect to the horizontal, so as to permit the recovery by natural flow of the eventual oil losses or other liquid leakages.

According to a particular feature of the invention, the manoeuvring control and warning members of the hoisting apparatus are all grouped onto a transportable wire remote control operator console 20, illustrated in Figure 7, with two potentiometric control handles 38, 38′, each including an incorporated amplifier and a setting solenoid for controlling, *via* the servo-valves, the hydraulic pressure of the different driving means of the hoisting apparatus. The right control handle 38′ permits the control of load lifting and orientation of the boom, and further comprises a small top button 49 for selectively suppressing breaking effects in laterally orientating the boom. The left control handle 38 permits control of raising and telescoping of the boom. Thus, to each angular position of the control handle there corresponds a determined position of the associated potentiometer, the output voltage of which is supplied to an oscillator furnishing to the coils of the servo-valves an average pilot current which is representative of the position of the control handle. An integrated logic unit, which generates a 10% threshold value, prevents the appearance of parasitic signals due to the vibrations. There is also shown, on the console 20, the above mentioned displaying members 21 and 23 and the first alarm and pre-alarm lights 40 arranged around an area Z′ on the console cover which correspnds in shape to the forbidden zone Z. There will further be provided the possibility of entirely testing the console by a separate console

testing system simulating the angle, length and pressure transducers by means of potentiometers, the proximity detectors by means of inverters and the servo-valves by means of lights.

In the embodiment shown, which is more particularly convenient for nuclear power plants, the crane 7 is mounted upon roller bearing rings, a recovery tank being arranged below the turret for recovering any possible liquid losses. The boom is comprised of three soldered box-like boom sections so as to have a reach variation between 8.50 m and 19.50 m as a result of simultaneous and continuous hydraulic telescoping of the boom sections. The maximum load is, for the minimum boom length, 9000 kg, and for the maximum boom length, 2700 kg. All the nut-and-bolt works are designed so that they cannot be lost and the crane is painted with a decontaminable paint. In order to achieve works on the building dome or on the travelling bridge, the crane can be operated from the gondola (line 49 in Figure 4), the gondola 37 having typically a serviceable capacity of 300 kg which is convenient for two workers and their tools.

Although it has been disclosed in relation to a preferred embodiment, the present invention is not limited thereto and many modifications and changes may be made therein within the scope of the appended claims.

CLAIMS

1. Hoisting apparatus for use in a confined space which comprises crane means having a cantilevered boom, which is mounted on a stationary support inside said space, power means for actuating the crane means, and manoeuvring means for controlling the power means so as to manoeuvre the crane means, and a first automatic detecting and controlling means adapted to prevent lateral displacement of the crane boom over at least a predetermined angular sector.

2. The apparatus of claim 1, further comprising a telescopic boom and a means for automatically detecting and determining the loading state of said boom having a load suspended therefrom.

3. The apparatus of claim 2, further comprising a second automatic detecting and controlling means for preventing vertical angular displacement of the crane boom over at least a pre-determined angular range.

4. The apparatus of claim 3, wherein the first detecting and controlling means includes automatic control means which may be selectively inhibited.

5. The apparatus of claim 4, wherein the second detecting and controlling means includes automatic control means which may be selectively inhibited.

6. The apparatus of claim 3, wherein each detecting and controlling means is coupled to a displaying device indicating that a forbidden boom configuration has been reached.

7. The apparatus of claim 6, which comprises a separate control console grouping the displaying devices and the crane manoeuvring means.

8. The apparatus of claim 7, wherein the first detecting and controlling means for automatically controlling angular displacement of the crane boom comprises proximity detectors cooperating with stationary cam sectors.

9. The apparatus of claim 8, comprising cylinder means for selectively angularly raising or lowering the boom, and wherein the means for automatically detecting and determining the loading state of the boom comprises at least one pressure transducer associated with the raising cylinder means of the boom, a detector means for detecting the length of the boom, and a detector means for detecting the tilting angle of the boom.

10. The apparatus of claim 9, further comprising a calculation unit receiving signals from the proximity detectors, the pressure transducer and the detector means for automatically terminating operation of the crane means having a load suspended from the boom upon occurrence of predetermined conditions as detected.

11. The apparatus of claim 10, wherein means are further provided for indicating imminent occurrence of the predetermined conditions.

12. Hoisting apparatus for use in a confined space substantially as hereinbefore described with reference to, and as shown in, the accompanying drawings.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1982. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

PUB-NO: GB002092099A
DOCUMENT-IDENTIFIER: GB 2092099 A
TITLE: A hoisting apparatus for use in a confined space and including a cantilevered telescopic boom
PUBN-DATE: August 11, 1982

ASSIGNEE-INFORMATION:

NAME	COUNTRY
SETRI	N/A
PPM SA	N/A

APPL-NO: GB08136653
APPL-DATE: December 4, 1981

PRIORITY-DATA: FR08025951A (December 5, 1980)

INT-CL (IPC): B66C023/94

EUR-CL (EPC): B66C023/94 , G21C019/02

US-CL-CURRENT: 212/280

ABSTRACT:

CHG DATE=19990617 STATUS=O> Hoisting apparatus, more particularly for use in a nuclear power plant to avoid moving suspended loads through the space above the reactor tank (2), comprises, mounted on a stationary structure (5) of said plant, a crane (7) having a telescopic boom (8) and three security systems, respectively an orientation security system (SSO) for forbidding a

determined angular range theta in angular lateral displacement when the boom reach is greater than Pm, a boom raising security system (LRF) limiting the raised position of the boom to a predetermined level, and a load state control (CEC) for insuring a permanent control with automatic cut-off for the boom in dependence of its extension length and of the lifted loads. Said security systems may be selectively inhibited. All the manoeuvring and indicating means are grouped on a transportable remote control operator console. □